INTERPRETATION OF MUTUAL POSITIONAL ERRORS OF IDENTICAL POINTS IN DIGITAL TECHNICAL MAP OF OSTRAVA CITY AND DIGITAL CADASTRAL MAP IN CADASTRAL DISTRICT OF HOŠŤÁLKOVICE

VYHODNOCENÍ VZÁJEMNÝCH POLOHOVÝCH ODCHYLEK IDENTICKÝCH BODŮ DIGITÁLNÍ TECHNICKÉ MAPY MĚSTA OSTRAVY A DIGITÁLNÍ KATASTRÁLNÍ MAPY V KATASTRÁLNÍM ÚZEMÍ HOŠŤÁLKOVICE

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Abstract

This paper deals with the comparison of two map bases in the cadastral district of Hošťálkovice on the map sheet of Opava 0-9/44. The first one is the Digital Technical Map of Ostrava City (DTMOC) and the other is the Digital Cadastral Map (DCM). The determination of mutual positional errors is important when analysing the usability of the data taken from the DCM for completing and updating the DTMOC.

Abstrakt

Tento příspěvek se zabývá porovnáním dvou mapových podkladů v katastrálním území Hošťálkovice na mapovém listu Opava 0-9/44. Prvním z nich je Digitální technická mapa města Ostravy (DTMMO), druhým je Digitální katastrální mapa (DKM). Určení vzájemných polohových odchylek je důležité při posouzení využitelnosti dat, převzatých z DKM, pro doplnění a aktualizaci DTMMO.

Key words: digital technical map, digital cadastral map, co-ordinate error, positional error

1 INTRODUCTION

The assessment of the quality of map bases is an actual theme in the period of the great expansion of geoinformation systems (GIS). Particularly, digital technical maps (DTM) that began to emerge in the early nineties of the last century are used to create GIS. For economic reasons, the attempt to simplify the updating of the DTM is in the first place, and therefore the data are taken from individual administrators of utility networks, and possibly supplemented with an additional information in cooperation with construction and cadastral offices. However, if the data taken are mutually and towards the DTM positionally inconsistent, there may be some problems in the practical use of the DTM.

2 BASIC KNOWLEDGE

When creating the Digital Technical Map of the Ostrava City (DTMOC) the compilers are required to comply with the third class of survey accuracy according to the former technical norm CSN 013 410 "Large scale maps - General provisions" [1]. Today, instead of the term "class of survey accuracy" the denotation "quality code of point" is used. Part of the Digital Cadastral Map (DCM) is a list of coordinates of points of detailed survey. Each point of detailed survey is marked with a relevant quality code according to the determination accuracy of its coordinates, or according to its origin (see Table 1).

Based on these fundamental findings one can assume that the point coordinates exported from the DTMOC and the coordinates of identical points of detailed survey exported from the DCM, having the quality code 3, will show deviations against each other corresponding to a mean basic coordinate error ≤ 0.14 m (see Tab 1).

This article deals with the evaluation of identical points in the DTMOC and the DCM in the cadastral district of Hošťálkovice in terms of their mutual positional accuracy. Specifically, the area restricted by the map sheet of Opava 0-9/44 has been evaluated.

Tab. 1 Quality codes of points of detailed survey [2]

Quality code	According to	
	Accuracy	Origin
	Point whose coordinates have been determined with a mean coordinate error	Point digitalized from an analogue map at a scale
3	≤ 0,14 m	-
4	> 0,14 m a ≤ 0,26 m	-
5	> 0,26 m a ≤ 0,50 m	-
6	≤ 0,21 m	1:1000, 1:1250
7	> 0,21 m a ≤ 0,50 m	1:2000, 1:2500
8	> 0,50 m	1:2880 and other above non-mentioned

3 PROCEDURE OF ASSESSMENT OF COORDINATE ERRORS

In order to evaluate coordinate deviations 580 identical points were used. Exclusively corners of buildings were chosen. The reason is that only corners of buildings may be in most cases considered in the DTMOC and DCM as identical. Thus exporting both map bases we obtain two sets of identical points, which we compare against each other.

As mentioned before, a basic mean coordinate error shall not exceed the criterion u_{xy} = 0,14 m.

The basic mean coordinate error is given by the relation [3] :

$$m_{xy} = \sqrt{\frac{(m_x^2 + m_y^2)}{2}},$$

where:

m_x - mean error in the direction of coordinate x-axis [m],

m_y - mean error in the direction of coordinate y-axis [m],

From the respective pairs of identical points the coordinate errors were calculated as follows

$$\Delta x = x_k - x_t,$$

$$\Delta y = y_k - y_t,$$

where:

x_k , y_k – coordinates exported from the DCM [m],

x_t , y_t – coordinates exported from the DTMOC [m],

Two mutually tested sets are some "samples" of basic sets. Therefore, to calculate the mean coordinate error we use the formula for calculating the mean "sample" coordinate error [2]:

$$s_{xy} = \sqrt{\frac{(s_x^2 + s_y^2)}{2}},$$

where:

s_x - mean sample error in the direction of coordinate x-axis [m],

s_y - mean sample error in the direction of coordinate y-axis [m],

We calculate the mean sample coordinate errors in direction of individual axes from the relations [2] :

$$s_x = \sqrt{\frac{\sum_{j=1}^{N} \Delta x_j^2}{k \cdot n}}, \quad s_y = \sqrt{\frac{\sum_{j=1}^{N} \Delta y_j^2}{k \cdot n}},$$

where:

Δx_j – coordinate difference of identical points in the direction of coordinate x-axis [m],

Δy_j – coordinate difference of identical points in the direction of coordinate y-axis [m],

n – number of pairs of identical points in the tested sample [-] ,

k – coefficient whose value is $k = 2$ for the pairs of identical points of the same accuracy [-].

Both map bases may be considered identical provided the two following conditions are met [2] :

- mean error in the position u_p of the individual points does not exceed the allowable deviation $2u_{xy}$, while at least 60% of the assessed deviations does not exceed the value $u_{xy} = 0{,}14$ m,
- mean sample coordinate error s_{xy} meets the criterion $s_{xy} \le 0{,}15$ m for n in the interval from 100 to 300 points and $s_{xy} \le 0{,}14$ m for $n > 300$ points.

In the tested sample there is 580 identical points and so we have to meet the condition $s_{xy} \le 0.14$ m. With respect to a relatively large number of tested points one can assume that this sample will show the characteristics of normal distribution. We make sure of it through the test for fit, by which we objectively review the sample normality. Prior to calculate the sample characteristics, we however have to ensure its homogeneity, thus to test outliers. A suitable tool for assessing the outliers in large samples ($n > 25$) is the Grubbs' test. Thus we formulate a null hypothesis H_0 and an alternative hypothesis H_1:

H_0: The value u_{pi} is not an outlier,

H_1: The value u_{pi} is an outlier,

The test criterion of the Grubbs' test is

$$T = \frac{\left| u_{pi} - \bar{x} \right|}{s},$$

where:

u_{pi} – mean error in the position of point [m],

$\bar{x}$ – arithmetic mean of sample [m],

s – standard sampling error [m].

According to the tables of critical values of the Grubbs' T-distribution, we determine gradually the value T_k of critical region for relevant values n and calculate the values of the test criterion, comparing them with the limit of the critical region. If the test leads to the conclusion that the extreme value should be excluded from the sample, it is necessary to re-construct all the sample characteristics (from the sample without any extreme value) for further possible calculations [5]. We choose the significance level $\alpha = 0{,}05$. The following Table 2 clearly shows that we excluded in this way 20 values, which are outliers according to the tests.

Tab. 2 Testing outliers of positional deviations

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**	**21.**
n	580	579	578	577	576	575	574	573	572	571	570	568	567	566	565	564	563	562	561	560	559
$\bar{x}$	0,30	0,29	0,29	0,29	0,28	0,28	0,28	0,27	0,27	0,27	0,27	0,27	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26
s	0,27	0,25	0,22	0,21	0,19	0,17	0,15	0,15	0,14	0,13	0,13	0,12	0,11	0,10	0,10	0,10	0,10	0,09	0,09	0,09	0,09
u_p	3,08	3,03	2,29	2,25	2,18	2,11	1,42	1,37	1,28	1,25	1,18	1,16	1,13	0,79	0,76	0,73	0,70	0,67	0,61	0,59	0,57
T_k	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59	3,59
T	10,1	11,0	9,00	9,52	10,0	10,6	7,40	7,45	7,20	7,33	7,16	7,75	7,93	5,12	4,95	4,76	4,55	4,33	3,76	3,60	3,42

Eliminating the outliers gradually, the sample size n diminishes, decreasing also the values of arithmetic mean, standard deviations and test criterion. For the 21st tested value the test criterion is less than the critical region limit and therefore we do not reject the hypothesis H_0 any longer. By testing the outliers we reduced the sample size to $n = 559$ and have it ready for the test of normality. Thus we formulate a null hypothesis H_0 and an alternative hypothesis $H_{1:}$

H_0: The tested sample is derived from the basic sample with normal distribution,

H_1: The tested sample is not derived from the basic sample with normal distribution.

We can divide the test for fit into two cases of normal distribution models, which are specified (we know the values of variance and mean) or not specified (mean and variance are estimated from sample values). The differences between these events become evident in the distribution of test statistic and also in decision-making whether the calculated value of test statistic falls in the critical region. The used statistical tests involve such as the Pearson's test, Kolmogorov - Smirnov, Shapiro - Wilk. The best known and most widely used is the Pearson's test, which is particularly suitable for large sample sizes (n > 50) and therefore it was also chosen in our case. Let $X_1, X_2, ..., X_n$ be independent random variables, each with the distribution N (0,1), then the random variable

$$Y = X_1^2 + X_2^2 + ... + X_n^2,$$

has the distribution χ^2 (chi-square) with ν degrees of freedom, which is denoted as $\chi^2(\nu)$. With increasing number of degrees of freedom, the density of this distribution is increasingly approaching the shape of the density of normal distribution.

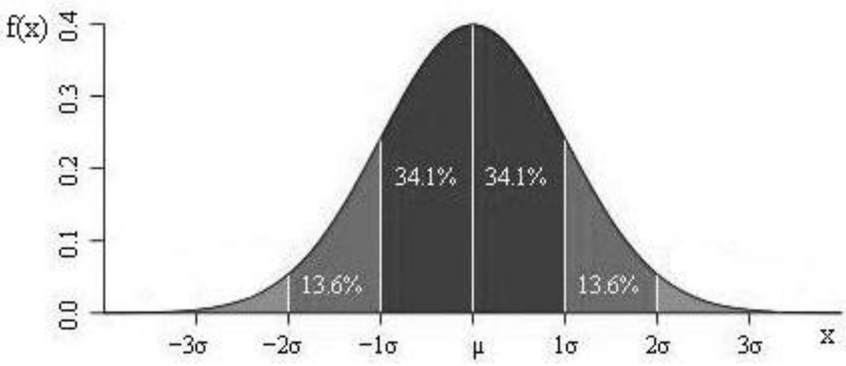

Figure 1 The probability density function of the normal distribution (www.wikipedia.org)

We divide the sample of size n = 559 into k intervals according to the Sturge's rule

$$k \approx 1 + 3{,}3 \log n.$$

It follows from this formula that k = 10, and as we by testing the outliers obtained a sample whose values are in the interval <0, 0.57>, the class interval width h is obtained by dividing the largest value by the parameter k and rounding it to the centimetres. It follows that h = 0,06, with frequencies n_j (j = 1, 2, ..., k). We denote the upper limits of each interval as u_{pj}.

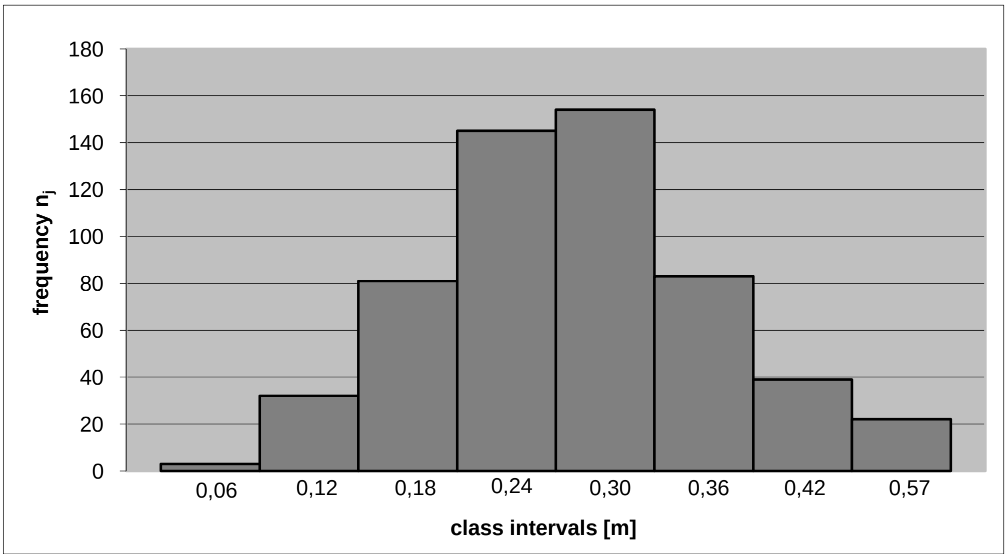

Figure 2 Frequency distribution of coordinate deviations

We calculate the theoretical class frequencies for the sample derived from the basic sample with a normal distribution N(μ, σ^2). The upper limits of class intervals must be converted to the values of standard variable.

$$u_j = \frac{u_{pj} - \mu}{\sigma},$$

where:

μ – mean of normal distribution [m],

σ – standard deviation of normal distribution [m],

u_{pj} – upper limits of each interval [m].

In our case we do not know the values μ and σ and therefore instead of μ parameter we substitute the value of sample mean and replace the σ parameter with the value of standard sampling error

$$u_j = \frac{u_{pj} - \bar{x}}{s}.$$

For each j we find the corresponding figures of the distribution function of standard normal distribution $\phi(u_j)$. Furthermore, we determine the theoretical relative and absolute class frequencies

$$\pi_j = \phi(u_j) - \phi(u_{j-1}) \text{ a } n\pi_j.$$

The necessary test condition is that the hypothetical frequencies $n\pi_j$ in each class are greater than 5. Provided this condition is not met, it is necessary to combine this class with a neighbour class. We obtain the value of test statistic by calculating the formula

$$\chi^2 = \sum_{j=1}^{k} \frac{(n_j - n\pi_j)^2}{n\pi_j}.$$

The value of critical region for the normality test at a significance level α is then:

$$\chi^2 > \chi^2_{1-\alpha}(k - c - 1),$$

where:

k – number of class intervals [-]

c - parameter, which is for incompletely specified models (we estimate the mean and the standard deviation) equals to 2 and for fully-specified model $c = 0$ [-],

1-α – quantile distribution χ^2 [-].

Tab. 3 Scheme of calculation of test statistic χ^2

u_{pj}	n_j	u_j	$\phi(u_j)$	π_j	$n\pi_j$	$n\pi_j$	n_j	$\frac{(n_j - n\pi_j)^2}{n\pi_j}$
0,06	3	-2,16	0,015	0,015	8,39	8,39	3	3,46
0,12	32	-1,50	0,067	0,052	29,07	29,07	32	0,30
0,18	81	-0,84	0,200	0,133	74,35	74,35	81	0,59
0,24	145	-0,19	0,425	0,225	125,78	125,78	145	2,94
0,30	154	0,47	0,681	0,256	143,10	143,10	154	0,83
0,36	83	1,13	0,871	0,190	106,21	106,21	83	5,07
0,42	39	1,78	0,962	0,091	50,87	50,87	39	2,77
0,48	9	2,44	0,993	0,031	17,33	21,24	22	0,03
0,54	8	3,10	0,999	0,006	3,35			
0,57	5	3,42	1,000	0,001	0,56			

The calculations of test characteristics, schematically illustrated in Table 3, involve the parameters of arithmetic mean and standard deviation calculated in the last column of Table 2. The condition $n\pi_i > 5$ was not met in the last two classes, and therefore they were merged with a neighbour class, as can be seen from Table 3. Merging the classes decreased their total number, and therefore the formula for calculating the critical region involve the parameter of a reduced number of classes k_r, which is in our case equal to 8 and therefore

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$$\chi^2 > \chi^2_{1-\alpha}(k_r - c - 1) = \chi^2_{1-\alpha}(5) = 11{,}1.$$

Significance level α = 0,05 was chosen. Adding up the values in the last column of Table 3 we get the test characteristics χ^2 = 15,99, and this value falls into the critical region. Therefore, we reject the null hypothesis H_0 that the tested sample comes from the basic sample with a normal distribution and accept the alternative hypothesis H_1.

The information about the shape of distribution provides also the descriptive characteristics of skewness and kurtosis (excess). This assessment is however inaccurate and serves rather as an additional information to the above methods. The skewness *a* expresses the symmetry of distribution of values around the mean and the kurtosis *e* expresses, how the values are concentrated around the mean

$$a = \frac{\sum_{i=1}^{n}(u_{pi} - \bar{x})^3}{ns^3} = 0{,}58 \text{ and } e = \frac{\sum_{i=1}^{n}(u_{pi} - \bar{x})^4}{ns^4} - 3 = 0{,}93.$$

For the sample with a normal distribution their values are approaching 0, but only rarely are exactly equal to 0. The calculations show a slight asymmetry *a* = 0,58 and also according to *e* = 0,93 it is clear that this is not a sample of a normal distribution.

The characteristics of normal distribution show that 68,3% of deviations (according to [4]) in the basic sample does not exceed the criterion u_{xy} = 0,14 m. In practice, we expect some deviation in test sample from ideal normal distribution, so the requirement according to [2] is more moderate, thus 60%. Furthermore, for a normal distribution 4,5% of the results may reach deviations greater than twice the criterion u_{xy} (according to [4]). In our case, the percentage of such great deviations in test sample is much higher (see below). Points with very large deviations are usually excluded from the test (assuming that these two points are not identical). For comparison of the map bases in our tested region we do not exclude these pairs of points, in particular due to their large number. Such large proportion of excessive deviations shows certain inconsistencies between the map bases, which we would not most likely unveil by exclusion of the relevant points and could not further assess. Only 21 points will be excluded, which fall to the critical region in the test of outliers.

4 ASSESSMENT OF COORDINATE DEVIATIONS

In order to evaluate coordinate deviations 559 identical points were used. The diagram of distribution of identical points on the map sheet of Opava 0-9/44 is shown in Figure 3. Efforts were made to deploy the selected points evenly across the map sheet, but due to the different density of housing an equal distribution of test points was not achieved. It was confirmed also by the Pearson's test for fit. The area of interest, restricted by the limits of the coordinates of evaluated points Y_{max}, Y_{min} a X_{max}, X_{min} was split to k = 8 equally sized rectangles (see Table 4) with the expected frequencies

$$n_{oj} = \frac{n}{k} = \frac{559}{8} = 69{,}875.$$

Tab. 4 Diagram of actual frequencies of identical points on the area of interest

50	35
70	45
81	113
58	107

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Figure 3 Diagram of distribution of identical points on the map sheet

The calculation of the critical region at a significance level α= 0.05 was performed according to the formula

$$\chi^2 > \chi^2_{1-\alpha}(k-c-1) = \chi^2_{1-\alpha}(8-1-1) = \chi^2_{1-\alpha}(6) = 12{,}6.$$

Parameter c = 1 is chosen, assuming a uniform distribution. The value of test characteristics χ^2 = 82,05 was calculated in Excel and is significantly higher than the limit of the critical region. Based on the results of statistical cluster analysis in the area of interest one can assume that at a significance level α = 0,05 the distribution of identical points in the tested area is not uniform.

After calculating the coordinate deviations larger differences were found in individual identical points than we expected according to the accuracy of the map bases. The number of points, where $u_p \leq u_{xy}$, is only 53. This represents only 9,48% of the total number of the test points. At the same time the condition $u_p \leq u_{xy}$ must be met by at least 60% of the test points. In our case, it would then mean 335 points. This shows very clear discrepancy between the two map bases. Another condition is that none of the tested deviations exceed the allowable deviation $2u_{xy}$. This criterion is met by 364 points. It is 65,12% of the total number of the identical points. The last condition is a convenient value of the mean sample coordinate error. The calculated value s_{xy} = = 0,19 m exceeds the permitted criterion. The median value of all tested points is 0,25 m. The results of calculations are summarized in Table 5.

Tab. 5 Results of calculations of coordinate deviations

Condition	Number of points	Percentage
$u_p \leq u_{xy}$	53	9,48 %
$u_p \leq 2u_{xy}$	364	65,12 %
$u_p > 2u_{xy}$	195	34,88 %

Table 5 shows also a great number of identical points, whose coordinate deviations are beyond the allowable deviation $2u_{xy}$. The characteristics of normal distribution show that approximately 4,5% of the results can achieve deviations more than twice the criterion u_{xy}. So it is considerably less than indicated in Table 5. These calculations confirm the results of the tests of normality.

All the above facts point out to the disparity between the two map bases. For these reasons, the graphical representation of mutual shifts (see Figure 4) is interesting, based on which we are able easily to determine the overall nature of the coordinate deviations. The important information was primarily the assessment of shifts in terms of their randomness of orientation. The identical points were loaded into a graphic file and the relevant pairs were connected by a line segment. These line segments were magnified 40x for clarity. The graph shows clearly extremely large deviations for identical points that were excluded during the tests of outliers. What is

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interesting it is a clearly visible southeast orientation of the shifts for the majority of investigated pairs of identical points. The visual assessment of the shift directions from the graphical representation is only indicative and is of a subjective nature. The objective assessment of the shift directions was carried out using the statistical analysis of directional data.

Figure 4 Graphical representation of the mutual shift of map bases

First, bearings σ_i of the individual pairs of identical points were calculated. A bearing is an oriented angle formed by a line connecting two points in the positive direction of X axis, it takes only positive values from 0^g to 400^g namely clockwise. The calculated values for 559 pairs of identical points were re-tested for outliers by the Grubbs' method described above. Ten outliers were excluded and thus 549 bearing values entered further calculations (see Tab. 6).

Tab. 6 Testing the outliers of bearings

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**
n	559	558	557	556	555	554	553	552	551	550	549
$\bar{x}$	340,83	340,57	340,33	340,68	341,03	341,30	341,57	341,79	342,01	342,20	342,01
s	34,13	33,60	33,16	32,14	31,13	30,48	29,85	29,41	28,97	28,65	28,31
σ_i	86,08	73,36	145,11	150,00	189,49	192,69	217,72	220,48	237,12	50,00	260,18
T_k	3,586	3,586	3,586	3,586	3,585	3,585	3,585	3,584	3,584	3,584	3,584
T	4,26	3,95	5,89	5,93	4,87	4,88	4,15	4,13	3,62	3,76	2,89

The next step was to perform the data normality test. The skewness a and the excess e are equal to zero for a normal distribution and in this case the results are quite clear

$$a = 0{,}65 \text{ and } e = 1{,}33.$$

It is not then a sample with a normal distribution, so based on these results we proceeded to a non-parametric testing of mean using the Wilcoxon test for one sample. The test assumes a continuous symmetric distribution of data. The calculation procedure results from the differences between the calculated values of bearings and the expected value of the median μ_0. Thus we formulate a null hypothesis H_0 and an alternative hypothesis H_1:

H_0: Expected value of the median μ_0 equals to the mean of the sample,

H_1: Expected value of the median μ_0 is not equal to the mean of the sample.

The sum of the sequence of differences σ_-, in which the values of bearings were below the expected median, should be approximately the same as the total value of the sequence of differences σ_+, in which the values of bearings were greater than the expected median. The test of the null hypothesis H_0 and the alternative hypothesis H_1 will be made for the smaller of the two values σ_- and σ_+. For the sample size n > 25 we can use the approximation by normal distribution

$$z = \frac{\sigma_{+-} - E(\sigma)}{\sigma_\sigma},$$

where:

σ_{+-} – the smaller of the two values σ_- a σ_+ [-],

$E(\sigma)$ – theoretical mean σ [-],

σ_σ – theoretical standard deviation σ [-].

The formulas for calculating the theoretical values of mean and standard deviation are as follows

$$E(\sigma) = \frac{n(n+1)}{4} \text{ and } \sigma_\sigma = \sqrt{\frac{n(n+1)(2n+1)}{24}}.$$

If the absolute value of the test statistic z is greater than the critical region limit $\pm z_{\alpha/2}$ at a significance level α, we refuse the null hypothesis H_0 and accept the alternative hypothesis H_1. For the significance level α = 0,05 and sample size n = 549 the following applies

$$E(\sigma) = 75488, \ \ \sigma_\sigma = 3718, \ \ z_{\alpha/2} = 1{,}96.$$

The values σ_- a σ_+ were calculated in Excel, the value of the expected median of sample was chosen μ_0 = 340^g and for this value of bearing the following values were calculated

$$\sigma_- = 80565 \text{ and } \sigma_+ = 70410.$$

Followed by the calculation of test statistic z, into which the smaller of the two calculated values σ_- and σ_+ enters

$$z = \frac{70410 - 75488}{3718} = -1{,}37.$$

The absolute value of the test statistic z is smaller than the critical value $z_{\alpha/2}$ = 1,96 and based on these results, we may not reject the null hypothesis H_0 at the significance level α = 0,05. The estimated median μ_0 = 340^g was then tested by the Wilcoxon non-parametric test for one choice and this bearing corresponds to the mean of the sample at the chosen level of significance. The approximate southeast orientation of the shifts of the DTMOC compared to the DCM was statistically confirmed.

When creating maps some distortions or coordinate system shifts may occur. These deviations appear due to various influences, such as instrument errors, atmospheric conditions, experience of surveyor, or methods of gathering and processing the measured data.

Let us suppose a region of interest, where we investigate the positional accuracy of map bases. These maps are shifted compared to the coordinate system. If we get connected to the identical points located in this area of interest (i.e. they show the same shift), and survey for control points of planimetry, we would find only the mutual positional and geometric accuracy of these points of detailed survey. The shift throughout the region remains undisclosed. It is possible that if we work only in one tested map base, it would show the accuracy corresponding to the quality code 3. This assumption can be confirmed only by a control survey of identical points, by connecting to surrounding points of detailed survey contained in the tested map base. For most practical applications a possible shift of the map base compared to the coordinate system could be probably omitted. But if the map base is used only without adding the data from another sources that may be inconsistent positionally.

5 CONCLUSIONS

Testing the identical points exported from the DTMOC and the DCM in the cadastral district of Hošťálkovice showed a disparity of both map bases in this area. The results of these tests may be a signal for caution when taking data from the DCM to the DTMOC. For other utilization of the DTMOC positional and geometric inaccuracies in the representation of planimetric elements may bring some complications. Especially for the projects being susceptible to inaccuracies in the positional arrangement of planimetric features compared to the reality determined in the field. It should be emphasized that the results do not show a lower accuracy of one or the other map base. If we work only in the DTMOC or only in the DCM, it is possible that each separate map base would show a guaranteed accuracy. Certainty in this respect we can get by surveying identical points in the field and connecting them to nearby points of planimetry, which are included in the tested map base. In this way we determine the mutual positional and geometric accuracy of the tested points. We can call it an inside accuracy of the given map base.

In the next phase an independent survey of the DTMOC identical points will be conducted straight in the field with connection through the GNSS technology. With this connection method it will be possible to determine, whether the DTMOC shows a shift compared to the coordinate system of the Uniform Trigonometric Cadastral Network (S-JTSK), which is realized by the network of trigonometrical points stabilized in the field in the vicinity of the tested area. Thus, the test of the outside accuracy of this map base will be performed.

REFERENCES

[1] ČSN 01 3410. Mapy velkých měřítek – Základní a účelové mapy., 1990.

[2] ČÚZK: *Vyhláška č. 26/2007 Sb.*, kterou se provádí zákon č. 265/1992 Sb., o zápisech vlastnických a jiných věcných práv k nemovitostem, ve znění pozdějších předpisů, a zákon č. 344/1992 Sb., o katastru nemovitostí České republiky (katastrální zákon), ve znění pozdějších předpisů, (katastrální vyhláška).

[3] VYKUTIL, J. *Teorie chyb a vyrovnávací počet*. 2nd ed. Brno : VUT v Brně, 1988. 309 s.

[4] DOLEŽALOVÁ, J., PAVELKA, L. *Pravděpodobnost a statistika*. 1st ed. Ostrava : VŠB – Technická univerzita Ostrava, 2005. 176 s. ISBN 80-248-0948-6.

[5] OTIPKA, P., ŠMAJSTRLA, V. *Pravděpodobnost a statistika.* Ostrava : VŠB – Technická univerzita Ostrava, 2010. 268 s. ISBN 80-248-1194-4.

RESUMÉ

Článek se zabývá porovnáním dvou mapových podkladů v katastrálním území Hošťálkovice na mapovém listu Opava 0-9/44. Prvním z nich je Digitální technická mapa města Ostravy (DTMMO), druhým je Digitální katastrální mapa (DKM). U DTMMO je garantováno dodržení kódu kvality 3 pro podrobné body polohopisu a v DKM se v testované oblasti také vyskytují body s kódem kvality 3. Pro testování bylo použito 580 identických bodů s tímto kódem kvality, rozmístěných na daném mapovém listu. Z výsledků statistických analýz vyplývá určitá nesourodost obou mapových podkladů. Výběrová střední souřadnicová chyba přesahuje povolené kritérium. Testy směrových dat ukazují na určitý posun DTMMO vůči DKM přibližně jihovýchodním směrem, což je patrné i z grafického znázornění jednotlivých posunů. Určení vzájemných polohových odchylek je důležité při posouzení využitelnosti dat, převzatých z DKM, pro doplnění a aktualizaci DTMMO. Výsledky neukazují na nižší přesnost jednoho nebo druhého mapového podkladu.

V další fázi bude provedeno nezávislé zaměření identických bodů DTMMO přímo v terénu s připojením pomocí technologie GNSS. Díky tomuto způsobu připojení bude možné zjistit, jestli DTMMO vykazuje nějaký posun vůči S-JTSK, který je realizován sítí trigonometrických bodů stabilizovaných v terénu v blízkém okolí testované oblasti.